



**U.S. Army Corps  
of Engineers**

*Kansas City District*

**FIELD SAMPLING PLAN**

**Preliminary Assessment/Site Inspection  
- Former St. Louis Ordnance Plant  
St. Louis, Missouri**

Final Submittal

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**TapanAm Associates, Inc.**  
*Consulting Engineers Scientists Architects*

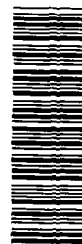
201 West 135<sup>th</sup> Street, Suite 100  
Kansas City, Missouri 64145  
816 941 6100 Fax 816 941 6100  
[tapan@tapanam.com](mailto:tapan@tapanam.com)

Site St Louis Ordnance Plant  
ID MO82100224645  
Break 11 11

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## 1 0 INTRODUCTION AND PROJECT DESCRIPTION

This Preliminary Assessment/Site Inspection (PA/SI) Work Plan has been prepared by TapanAm Associates, Inc (TapanAm), under Contract Number DACW 41-94-D-9010, Delivery Order 0002. The PA/SI Work Plan consists of a Field Sampling Plan (FSP), a Quality Assurance Project Plan (QAPP), a Site Safety and Health Plan (SSHP), and a Quality Control Plan (QCP). The FSP describes the procedures for field sampling of various sources and collection of samples along the contaminant migration pathways. The QAPP, SSHP, and QCP describe procedures, review methods, and documentation for data quality objectives, site safety, and quality control (QC) of the project. These documents have been developed in accordance with the requirements specified in the revised Scope of Work (SOW) dated June 1999, and the modified SOW dated August 16, 2000.

In accordance with the United States Army Corps of Engineers' (USACE) SOW, TapanAm is required to conduct a field investigation that produces data to support completion of United States Environmental Protection Agency (USEPA) Preliminary Ranking Evaluation score (PREscore). Further, TapanAm will use the following USEPA guidance documents to develop the sampling program: *Guidance for Performing Site Inspections under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA)*, EPA/540-R-92-021, Interim Final, September 1992, and *Improving Site Assessments Combined PA/SI Assessments*, Office of Solid Waste and Emergency Response (OSWER) Directive 9375.2-10FS, October 1999.

The scope of the PA/SI will include the following:

- ♦ Characterize and evaluate significant site sources,
- ♦ Characterize and evaluate significant pathways,
- ♦ Evaluate releases and targets exposed to contamination, and
- ♦ Collect sufficient data to support the Hazard Ranking System (HRS) and completion of an USEPA PREscore.

## 1 1 PHYSICAL SETTING

### 1 1 1 Location

The Hanley Area of the former SLOP is located on the western boundary of St. Louis, Missouri, city limits. The facility lies approximately three miles west of the Mississippi River and 0.25

miles south of the intersection of Interstate 70 and Goodfellow Boulevard (ICF, 1991) The site maps are shown on Figures 1 and 2

## **1 1 2 Physiography, Topography, and Drainage**

### *Physiography*

The site is located at the western limits of the city of St. Louis, Missouri, which in turn is located on the northwestern flank of the Ozark Plateau in the Dissected Till Plains Physiographic Province (Miller, 1974) The topography of the Dissected Till Plains Province is gently rolling hills with elevations ranging from 500 to 700 feet above Mean Sea Level (AMSL)

Topographic slopes are local reflections of the very gentle regional dip of about 55 feet per mile to the northeast (Harrison, 1997) These gentle dips are interrupted by several narrow zones of deformation which become very intense in some of the zones Variations in hardness of the Paleozoic rocks are shown by escarpments on the more resistant formations that face southwestward, parallel to the Ozark uplift The stratigraphy of geologic formations underlying St. Louis County is characterized as sedimentary formations Glaciers covered the area twice during the Pleistocene, however till deposits in the area are relatively thin and dissected

### *Topography*

The Hanley Area consists of 14.68 acres located within the 28-acre former Hazardous Chemical Area No. 2 The Hanley Area is located on a relatively flat terrace with elevations that range from 560 feet to 540 feet above MSL the National Geodetic Vertical Datum (NGVD), 1929 The site topography slopes steeply down to Goodfellow Boulevard along the east side of the site

### *Drainage*

More than 85 % of the ground surface at the SLOP site is covered by asphalt, concrete, buildings or other impervious materials (USACE Archives Search Report, 1993) Site terrain slopes toward the southeast and eventually drains into the Mississippi River

### **1 1 3 Meteorology**

The consistent pattern of climate in St. Louis County consists of cold winters and long, hot summers (Benham, 1979). The moist air from the Gulf of Mexico interacts with drier continental air in the spring and early summer producing heavy rains. The total annual precipitation is 33.8 inches. Thunderstorms occur on about 50 days each year with most occurring in the summer. The prevailing wind is from the south.

The average summer and winter temperatures are 77°F and 33°F, respectively. The average relative humidity in mid-afternoon is about 60 %. Average seasonal snowfall is 18 inches.

### **1 1 4 Soils**

The soil matrix at the Hanley Area of the SLOP site is characterized as an Urban land-Harvester complex, 2 to 9 % slopes according to the U. S. Department of Agriculture, Soil Conservation Service (SCS), 1979. This complex consists of approximately 65% urban land with intermingled areas of gently sloping and moderately sloping well-drained Harvester soils.

The urban land of this complex is covered by streets, parking lots, buildings, and other structures that obscure or alter the soils such that identification of the series is not feasible. The Harvester series consists of deep, moderately well drained soils on uplands. These soils formed in 12 to 40 inches of reworked loess fill material over truncated or buried loess soils. Permeability is moderately low in the Harvester soils with slopes ranging from 0 to 20 %.

### **1 1 5 Geology**

Geology of the region surrounding the SLOP site is essentially that of flat-lying sedimentary rocks, mostly limestone and dolomite. Rocks range in age from Precambrian to Holocene. The forces that produced the Ozark uplift controlled the regional structure of bedrock geology in the area (ICF, 1991).

#### **1 1 5 1 Regional Geology**

Regionally, the sedimentary rocks were deposited in shallow epicontinental seas (Miller, 1974). The present structural attitude of the rock units is the result of the compressional, tensional, and uplifting forces, which moved and altered units from their original depositional positions. The

Precambrian rocks, the Lamonte Sandstone, and the lower part of the Bonneterre Formation are the only units that do not outcrop in the area, but are present in the subsurface. Table 1 is a description of stratigraphic sequences in the St. Louis area (Miller, 1974). Figure 3 shows the geologic map of in the vicinity of the site (Harrison, 1997).

### *Overburden*

Alluvium deposits underlie the floodplains and terraces of the Mississippi, Missouri, and Meramec Rivers and extends over 277 square miles in St. Louis, St. Charles, and Jefferson Counties (Miller, 1974). The thickness of the alluvium is variable because of irregularities in the bedrock surface upon which it was deposited. The maximum known thickness of alluvium is 150 feet in the Columbia Bottoms near the mouth of the Missouri River. The alluvium is composed of clay, silt, sand, and gravel that in general becomes coarser grained with depth.

Modified loess is thickest along the bluffs and ridgetops. These deposits are generally 40 to 80 feet thick and consist of a clay-rich lower loess overlain by a silt-rich upper loess. These deposits were derived from glacial sources that were deposited during the Wisconsin Stage of the Pleistocene.

### *Bedrock*

Regionally, bedrock in the St. Louis area ranges in age from Ordovician (430 million years old) to middle Pennsylvanian (300 million years old). Mississippian age rocks of the St. Louis and St. Genevieve Formations lie unconformably beneath Pennsylvanian strata. The St. Louis area has a monocline structure that gently dips to the northeast. The structural attitude of the beds results from the compressional, tensional, and uplifting forces, which created a series of faults and fractures throughout the region.

## **1.1.5.2 Site Geology**

### *Overburden*

The overburden in the adjacent uplands, located approximately 1000 feet northeast of the Hanley Area, consists of yellowish-brown clayey silt (loess) and ranges in thickness from 13 to 28.5 feet (see Appendix K for boring logs). A sand and gravel layer, containing chert nodules, was encountered beneath most of the former Shell Plant Area near the interface between the

overburden and weathered shale bedrock. This permeable layer provides a potential preferential pathway for contaminant migration in the overburden groundwater. It is unknown if this sand and gravel layer exists beneath the Hanley Area.

### *Bedrock*

As previously stated, bedrock beneath the site is controlled by the Ozark uplift which is evident in the anticlinal, synclinal, and fault zone structures located in the area (Figure 4). The SLOP site is located approximately 1.5 miles east of the Cheltenham Syncline on the downwarped eastern limb and approximately 2.5 miles and 5 miles west of the Florissant Dome and the St. Louis fault zone, respectively. Two earthquake epicenters, magnitudes 1.5 m<sub>q</sub> (11/30/74) and 3.1 m<sub>q</sub> (9/20/78), were recorded approximately 10 miles north and south of the site, respectively.

Early Pennsylvanian age rocks of the Marmaton and Cherokee Groups make up the uppermost bedrock strata beneath the Hanley Area and are thought to be approximately 100 feet thick (ICF, 1991). These Pennsylvanian units unconformably overlie the Mississippian-age rocks of the St. Genevieve Limestone, which in turn unconformably overlies the St. Louis Limestone (Harrison, 1997). Regional subsurface structure, interpreted from boring and well logs, is shown in cross-section A-A' (Figure 5). This line of cross-section is located approximately 10 miles north of the SLOP site. It is anticipated that the bedrock strata beneath the site dips to the west-southwest, towards the axis of the Cheltenham Syncline.

## **1.1.6 Hydrogeology**

### **1.1.6.1 Regional Hydrogeology**

Large amounts of fresh water are stored in the bedrock and alluvium underlying the St. Louis area (Miller, 1974). Water occurs in the bedrock along fractures and bedding planes, in solution cavities in the limestone and dolomite, and in voids between the grains in sandstone. Major alluvial aquifers in the area are the water-saturated sands and gravels in the basal part of the alluvium underlying the floodplains of the Mississippi, Missouri, and Meramec Rivers. The alluvial aquifers are recharged by infiltration of stream water during sustained high-river stage and flooding, by direct precipitation, and by underflow from underlying and adjacent bedrock.

The bedrock aquifers receive recharge from precipitation falling directly on the area (Miller, 1974). Movement of water from the soil and subsoil into the bedrock takes place along fractures and solution openings in the rock.

Bedrock aquifers are divided into 5 groups (Table 1) and are as follows:

- ♦ Post-Maquoketa includes all bedrock above the Maquoketa Shale, which probably acts as a confining bed in the St. Louis area (Miller, 1974),
- ♦ Kimmswick-Joachim includes all aquifers between the base of the Maquoketa Formation and the base of the Joachim Formation and is not considered a good aquifer due to insufficient well yields to be considered an aquifer,
- ♦ St. Peter-Everton includes the St. Peter Sandstone and the Everton Formation,
- ♦ Powell-Gasconade includes all units in the Canadian Series of Early Ordovician age, and
- ♦ Eminence-Lamotte includes all units below the base of the Gasconade Dolomite.

Wells drilled into the bedrock aquifers in the St. Louis area encounter confined, or artesian, groundwater. Under artesian condition, recharge to bedrock aquifer mostly occurs from precipitation falling directly on the outcrop area but it may also occur from infiltration through the overburden aquifer within the site area if the two aquifers are hydraulically connected. The hydrostatic pressure, or 'head', in these aquifers raises the water level in the well above the point where it was first encountered during drilling. Any movement of groundwater is from areas of higher hydrostatic pressure to areas of lower hydrostatic pressure (Miller, 1974). This is exemplified by the Missouri Department of Natural Resources (MDNR) well search results which noted production well, log number 003522, to be located approximately 7 miles northeast of the site. This well is 655 feet deep, terminating in the Mississippian-age Burlington-Keokuk Limestone, and had a yield of 120 gallons per minute (gpm) and a static water level of 65 feet below ground surface (bgs) on the date of installation in February, 1936 (Appendix K).

#### **1.1.6.2 Site Hydrogeology (Overburden Aquifer)**

There are no shallow domestic wells, production wells, or monitoring wells located at the SLOP site. As mentioned previously, soil borings were drilled to investigate the overburden, at a location approximately 1000 feet northeast of the site. However, only one of the 9 boring logs, SWMW-7, had an initial recorded water level of 12 feet bgs.

It is anticipated that groundwater will be encountered in the overburden beneath the site at depths ranging from 15 to 45 feet bgs, largely dependent on the seasonal recharge from precipitation. Groundwater in the overburden is anticipated to flow downgradient to the east along the erosional bedrock surface (see Figure 2).

## 1.2 SITE HISTORY

### 1.2.1 Site Background

The construction of the SLOP was completed in May 1942. The area west of Goodfellow Boulevard was used for explosive production and storage. Hanley Industry, Inc. leased this area for receiving, loading, pressing, and testing of explosives. Hanley operated this site from 1959 through 1979. In 1960, the U.S. Army Reserve Center was formed south of the Hanley area and acquired the Hanley area in 1979. The former SLOP was operated during World War II, the Korean War, and the Vietnam War.

The Hanley Area is located on a relatively flat terrace covering most of the 14.7 acres. All of the buildings present in the Hanley Area (production Buildings 218A, 218B, and 218C, warehouse Buildings 219A, 219D, and 219G, and the frame buildings located inside the concrete-walled explosive containment bunkers) are in a state of poor repair (ICF, 1991). The site contains a number of underground rooms, tunnels for service utilities, an underground wastewater system, and a storm-water collection system. Currently the former Hanley Area is owned by the Army Reserve Center. Previous building description and uses (USACE Archives Search Report, 1993) are as follows:

#### *Building 218 Series*

Series 218 A, B, and C buildings are large T shaped brick buildings with anti-static floors in all 34 rooms that open to the building exterior. These buildings are interconnected by underground tunnels, which are connected to the basement rooms of each building. These buildings were used for primer and tracer mixing (1941-1945) and loading and mixing of explosives (1959-1979). Delay powder was loaded in the basement of 218A, under room 105. Other uses include non-explosive storage and burning of explosive contaminated rags.

### *Building 219 Series*

Buildings 219A, D, and G are large, single story, rectangular, brick buildings with a large control room with smaller rooms at each end. All rooms have orange colored glazed brick interior walls, anti-static composition floors, and wall and ceiling vents. The buildings have outside loading docks but do not have basements. Primer and tracer mixing took place in these buildings from 1941-1945. Smokeless powder was loaded throughout building 219A. Buildings 219D and 219G were used for administrative space from 1959-1979.

### *Building 219 Series*

Buildings 219B, C, E, F, H, and J are square, one room brick buildings with orange colored glazed tile interior walls and anti-static floors which were used as magazines. The roofs are clay tiles and 15-foot high concrete blast walls surround each of these buildings. Buildings 219B, 219C and 219H were used for open air drying of explosives from 1959-1979, whereas during this time 219E was used for lead azide production. Buildings 219F and 219J were used for burning of explosives. Buildings 219A, D, and G were used as laboratory buildings.

### *Building 220*

Building 220 is a large rectangular, one-story brick structure that was used for administrative space (1941-1945) and subsequently as an explosive laboratory (1959-1979). All rooms on the ground floor have orange colored glazed brick interior walls and anti-static compound floors. The basement of building 220 is a single large room that was used as a machine shop.

### *Building 227 Series*

The 227-series buildings consist of small one room, white buildings constructed of plasterboard interior walls, asbestos shingle outer walls, and anti-static compound floors. Each building is surrounded by a 15-foot high concrete blast wall approximately 18 inches thick. Explosives mixing operations took place in these buildings from 1941-1945. From 1959-1979 these buildings were used for the storage of sealed explosive containers.

### *Building 228 Series*

The 228-series buildings are of two types. Those at the eastern end are square brick buildings with orange colored glazed brick interior walls and anti-static compound floors. The buildings at the western end (228W, 228X, and 228Y) are long, rectangular structures with plasterboard interior walls and asbestos shingle outer walls. Building 228Z is an open bay. All of the 228-Series buildings are surrounded by a 15-foot high concrete blast wall. These buildings were used for powder storage (magazines) from 1941-1945, then abandoned.

### *Building 236*

Building 236 is a one-story brick building with a concrete floor and a double-car garage. This building was thought to have been used as a garage from 1941-1945, after which time it was not used.

## **1.2.2 Project History**

As stated in the previous section, the Hanley Area was used for research, development, manufacture, and testing of various explosives. Most of the buildings were used for loading detonators and primers and for explosive mixing.

In 1979 decontamination procedures were required to be conducted by Hanley as part of the lease termination. The extent of decontamination, and procedures used, were not well documented. The walls in the buildings were apparently washed down to a height of 8 feet above the floor. The wash water being discharged onto the ground outside the buildings. None of the magazines were washed down. The powder wells installed in 1941 received wastewater from buildings and magazines until 1945. These powder wells provided sedimentation collection before discharge to the sanitary sewer. Hanley was reported to have not used the existing powder wells located on the property.

## **1.3 SUMMARY OF EXISTING SITE DATA**

Three environmental investigations and one archive search report have been conducted at the former SLOP site, Hanley area. Previous investigations at the site include:

- ♦ "USATHAMA-Battelle Columbus Laboratories, June, 1981,
- ♦ "USATHAMA- Environmental Study", ICF Technology, Inc., November, 1991,

- ♦ "Site Investigation Report, Former SLOP, St Louis, Missouri", Harza Environmental Services, Inc , December, 1998

In 1981, Battelle surveyed the area for explosives and heavy metal contamination ICF Technology, Inc conducted a field screening survey to quantify the extent of asbestos and soil contamination in 1991 The USACE compiled an archives search report for SLOP in 1993 Further field investigation was performed by Harza in 1998 The results of the field sampling activities are described in the following sections

### **1 3 1 USATHAMA-Battelle Columbus Laboratories, 1981**

In 1981, Battelle surveyed the area for explosives and heavy metal contamination in and around 7 buildings, 54 magazines, 28 powder wells, and 5 sewer locations The findings showed heavy metal residues to be present on the interior surfaces of all buildings and in the aqueous discharge of the sewer system Additionally, explosive residues were found on the interior of several buildings and magazines and in the water of several powder wells draining buildings 218A and 218B Swipe samples for heavy metal analyses were composited by building number and magazine group and were reported in micrograms per square meter ( $\mu\text{g}/\text{m}^2$ ) Heavy metal concentrations ranged from below detectable limits to 24, 147, 32, and 102  $\mu\text{g}/\text{m}^2$  for silver, nickel, mercury, and cadmium, respectively Lead and chromium were found in all of the buildings surveyed Concentrations of chromium ranged from 26 to 515  $\mu\text{g}/\text{m}^2$  Lead concentrations ranged from 800 to 27,200  $\mu\text{g}/\text{m}^2$  Magazine 219E housed Hanley's lead azide reactor Magazine 219F, used for open burning of explosives, had the highest lead concentration of 5,840 mg/kg Concentrations of silver, mercury, and chromium were below detectable limits in all sewer samples

Explosive residues were found on the walls in buildings 218A, 218B, 218C and 220 as well as Magazines 219C, 219H, 227J, 227M, 227O, 228C, and 228F Explosive residues were also found in the standing water present in the powder wells draining buildings 218A and 218B No explosives were found in the discharge of the sewer system The presence of explosive residues in 218A, 218B, and 218C coincides with the explosive loading, mixing, and disposal operations that were conducted in these buildings from 1941 to 1979 Magazines 219C, 219H, 228C, and 228F were found to contain trace amounts of Cyclotetramethylenetetranitramine (HMX) in residues sampled from the

magazine interiors. The explosive chemical 2,4,6-Trinitrophenylmethylnitramine (Tetryl) was found in the water from the 7 powder wells draining buildings 218A and 218B with levels 4.0 and 4.6 ppb, respectively (Battelle, 1981).

### **1.3.2 USATHAMA- Environmental Study, ICF Technology, Inc., 1991**

In 1991, ICF collected 29 surface soil samples across the site to evaluate the presence of contamination potentially affecting surface runoff and groundwater. Two water samples were collected within the tunnel system to evaluate surface runoff. Results of the sampling indicated that surface soils are contaminated with lead at levels of concern. Contaminant migration pathways for lead include surface runoff and windblown dust. Water samples collected from the tunnels were contaminated with lead and an explosive, pentaerythritol tetranitrate (PETN) at a level of 20 micrograms per liter ( $\mu\text{g/L}$ ), which was also the method reporting limit. Asbestos containing materials were found to be present in most areas within the Hanley area. A leaking transformer containing high levels of polychlorinated biphenyls (PCBs) was dismantled, protectively wrapped, and was disposed of along with PCB-contaminated soils.

Recommendations included the appropriate management of asbestos in the Hanley area and characterization of powder wells and associated piping for the presence of contamination.

### **1.3.3 Site Investigation Report, Former SLOP, St. Louis, Missouri, Harza Environmental Services, Inc., 1998**

In 1998, Harza collected 21 surface soil samples, 4 sediment samples from the powder wells and sewer system, and 1 water sample from a powder well. The samples were analyzed for volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), explosives, and metals. Explosives contaminants were detected outside building 219F at concentrations of 3,300 and 9,730 micrograms per kilogram ( $\mu\text{g/kg}$ ) Cyclotrimethylenetrinitramine (RDX) and 1,480 and 1,700  $\mu\text{g/kg}$  HMX at 0-1 foot and 1-2 feet, respectively.

Metals found in surface samples include arsenic, barium, cadmium, chromium, lead, mercury, and silver. Principal organic compounds that were detected by SVOC analyses are polynuclear aromatic hydrocarbons (PAHs) such as phenanthrene, anthracene, fluoranthene compounds, pyrene compounds, benzo(a) anthracene, chrysene, and bis(2-ethylhexyl)phthalate.

ICF, 1991, states that SVOCs "were observed at trace levels ( $< 1$  ppm) in the background soil samples" and that "their presence is probably due to the proximity of the sampling locations to an asphalt parking lot" For the non-background samples ICF states that "The PAHs were detected at low levels, probably attributable to constituents present in the fill material" Harza, 1998, stated that SVOC contamination "may not result from past operations at the SLOP" Therefore, no SVOC analyses are planned for this PA/SI